The Atmospheric Re-Entry of UARS

The Upper Atmosphere Research Satellite (UARS) was launched in 1991. After 15 years of research, in 2005 its orbit was lowered from 550 km to 360 km as part of the orbital disposal of this retired satellite. Through atmospheric drag, the satellite began a slow continued descent from 352 km in 2008 to 320 km in 2011. By July, the pace quickened as the satellite steadily encountered a denser atmosphere. At the extrapolated rate of descent, it was predicted that the satellite would finally burn-up by September 23/24 - an event that intrigued and concerned millions of people who worried that some part of the satellite might strike them or do significant property damage.

The table below gives the perigee altitude in kilometers of the satellite at various dates in 2011 during its descent from orbit.

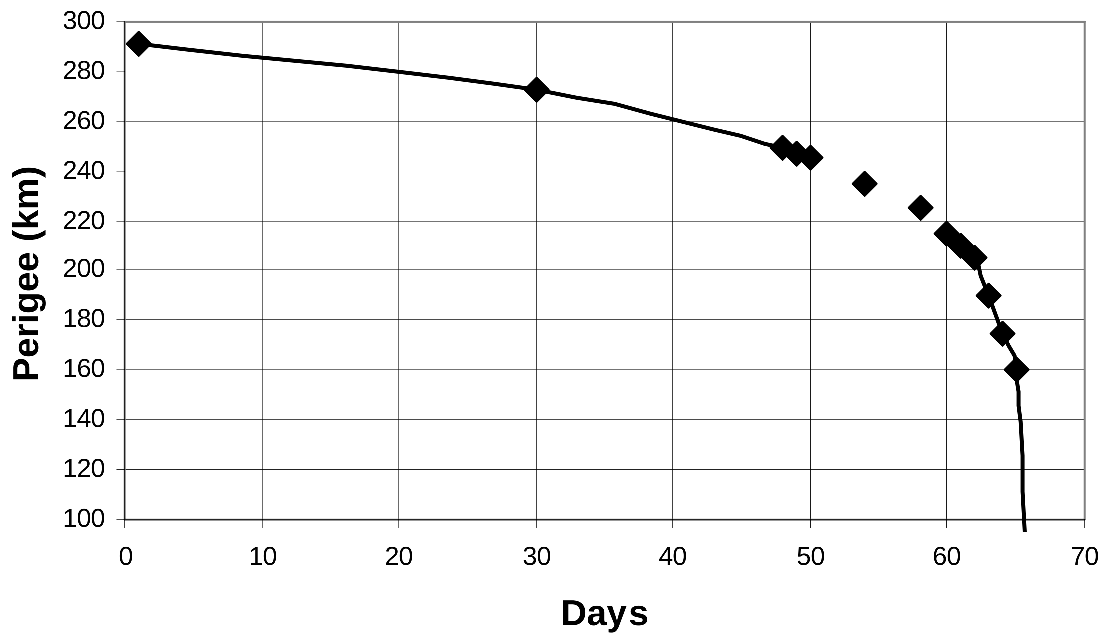
Date	Day	Altitude	Date	Day	Altitude
July 20	1	291	Sept. 17	59	220
August 19	30	273	Sept. 18	60	215
Sept. 6	48	249	Sept. 19	61	210
Sept. 7	49	247	Sept. 20	62	205
Sept. 8	50	245	Sept. 21	63	190
Sept. 12	54	235	Sept. 22	64	175
Sept. 15	57	230	Sept. 23	65	160
Sept. 16	58	225			

Problem 1 - Graph these points and connect the points with a line.

Problem 2 - What is the rate of altitude loss in meters per hour between A) August 19 and September 6? B) September 17 and 18? C) September 22 and 23?

Problem 3 - Can you construct a function that closely models the data and the shape of the plotted curve? When do you predict the satellite reaches zero altitude?

Problem 1 - Graph these points and connect the points with a line.



Problem 2 - What is the rate of altitude loss in meters per hour between A) August 19 and September 6? B) September 17 and 18? C) September 22 and 23?

Answer: A) R = (249 - 273)/(48 - 30)
= - 1.33 km/day x (1000 m/1 km)x(1 day/24h)
= **-56 meters/hour**.

B) R = **-208 meters/hour.**

C) R = **- 625 meters/hour.**

Problem 3 - Can you construct a function that closely models the data and the shape of the plotted curve? When do you predict the satellite reaches zero altitude?
Answer: This activity is facilitated by using Excel spreadsheets programmed with various 'guesses' until the modeled curve falls close to the actual curve. Students should quickly realize that because the rate of descent changes constantly, a linear equation using a constant 'slope' will not work. Hint: Divide each day number by 65 days to get x, then work with these 'normalized' day values. One function is

$$h = 291 - 6e^{3x^{3/2}}$$

Predicted date for h=0 is about x=1.18 or Day 77, which would be October 5th. More accurate modeling would account for the very rapid increase in the rates after September 20th which the model h(x) underestimates.